

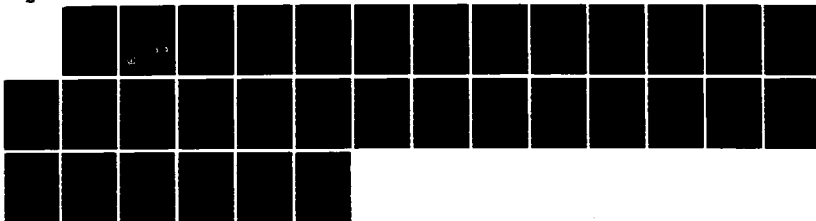
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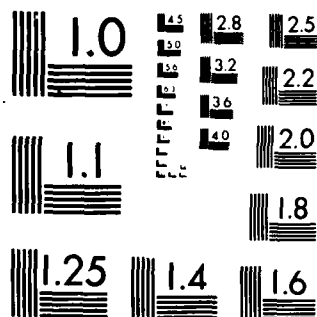
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# NAVAL SURFACE WEAPONS CENTER TECHNOLOGY TRANSFER REPORT (FY 85)

BY RAMSEY D. JOHNSON  
ADVANCED PLANNING STAFF

1 OCTOBER 1985

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## FOREWORD

The Naval Surface Weapons Center (NSWC) Technology Transfer Report (FY85) has been prepared in accordance with the format and content currently specified by the Office of Chief of Naval Research for Navy inputs in meeting the reporting requirements of the Stevenson-Sydler Technology Innovation Act of 1980 (Public Law 96-480).

The objectives of Navy technology transfer are (1) to disseminate non-critical technology, originally developed in support of military applications, for potentially alternative uses in the public and private sectors; and (2) to promote joint cooperative development programs that address problems of mutual concern to the Navy and other agencies or organizations. In pursuit of these objectives, the Navy transfers technical expertise to other Federal Government agencies; state and local governments; small and large businesses; nonprofit organizations; and such public service organizations as schools, hospitals, and foundations. In addition, technologies that have direct impact on the Navy mission and programs are transferred within, or into, the Navy. Transfers of hardware, software, management practices, and expertise are made in diverse fields, such as analysis and testing, communications, energy, environment, transportation, and marine technology. The Navy Technology Transfer Program provides unique services not available from the private sector and not in competition with that sector. The underlying philosophy and approach is to promote domestic technology transfer activities of non-militarily critical technical material that is approved for public release.

A substantial portion of the information in the Appendices of this report was contributed by NSWC technical staff members engaged in Center technology transfer tasks. Questions or requests for additional information should be referred to NSWC, Code D21, Mr. Ramsey D. Johnson, (301) 394-1505 or Autovon 290-1505.

Approved by:

*L. J. Fontenot*  
L. J. FONTENOT, Head  
Center Planning Staff

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## CONTENTS

	<u>Page</u>
1. ORGANIZATIONAL STRUCTURE FOR TECHNOLOGY TRANSFER . . . . .	1
2. ACCOMPLISHMENTS AND CURRENT EFFORTS SUMMARY. . . . .	3
3. INFORMATION DISSEMINATION AND WORKING RELATIONSHIPS. . . . .	3

Appendix

A	NARRATIVE SUMMARIES FOR NSWC FY85 TECHNOLOGY	
	TRANSFER RELATED PROJECTS . . . . .	A-1
	1. MANUFACTURING TECHNOLOGY. . . . .	A-1
	2. SOLID ROCKET BOOSTER (SRB) HAZARD STUDY . . . . .	A-2
	3. NASA SPACE SHUTTLE FRAGMENT HAZARDS . . . . .	A-2
	4. HYDROBALLISTIC FACILITY . . . . .	A-2
	5. GPS GEODETIC RECEIVER SYSTEM. . . . .	A-3
	6. HIGH ALTITUDE PARACHUTE DEPLOYMENT. . . . .	A-3
	7. DEPARTMENT OF TRANSPORTATION (COAST GUARD) SUPPORT. . . . .	A-4
	8. TOURMALINE GAGES. . . . .	A-4
	9. COMPUTER SCIENCE RESEARCH CONSORTIUM. . . . .	A-4
	10. SYSTEMS RESEARCH CENTER AT VPI/SU . . . . .	A-5
	11. IMPACT SENSITIVITY TESTS. . . . .	A-5
	12. EXPLOSIVE TRANSFER LINES EVALUATION . . . . .	A-6
	13. POSITRON LIFETIME STUDY . . . . .	A-6
	14. U.S. COAST GUARD DIVING EQUIPMENT PROGRAM . . . . .	A-7
	15. UNDERSEA WEAPONS TANK . . . . .	A-7
	16. HYDROGEN GAS GENERATOR. . . . .	A-7
	17. NITINOL RESEARCH ASSIST . . . . .	A-7
	18. RADIOGRAPHIC INSPECTION OF FUEL CELL INSULATORS . . . . .	A-7
B	NSWC FY85 TECHNOLOGY APPLICATION ASSESSMENTS . . . . .	B-1
	SOFTWARE RELIABILITY ANALYSIS (NSWC-TAA-85-001) . . . . .	B-2
	MAGNETIC DETECTION (NSWC-TAA-85-002). . . . .	B-4
	REAL TIME LAN COMMUNICATIONS (NSWC-TAA-85-003). . . . .	B-6
C	NSWC INVENTIONS AND PATENTS IN FY85 . . . . .	C-1
	DISTRIBUTION. . . . .	(1)

## 1. ORGANIZATIONAL STRUCTURE FOR TECHNOLOGY TRANSFER

a. Background. From a historical perspective, NSWC has been involved in technology transfer activities even prior to participating as a charter member of the Department of Defense Technology Transfer Consortium in 1971. This organization subsequently evolved into the Federal Laboratory Consortium, of which NSWC continues to be a contributing member. NSWC's role is necessarily limited since its R&D efforts are principally directed towards Navy requirements in the national security arena. Consequently, considerations of security classification and export control of unclassified critical technologies can severely constrain the release of technical information on an unrestricted basis. Furthermore, the work is often intrinsically oriented to naval applications, and considerable adaptive engineering (necessitating non-DoD funding sources and redirection of in-house resource allocations from mission areas) would be required to redirect the R&D to non-Navy uses. Within these general constraints, NSWC endorses and pursues technology transfer activities involving Center-wide R&D efforts.

b. Program Implementation

(1) Management. The Center's domestic technology transfer policy is administered by the Center Planning Staff (Code D21). The staff provides advanced planning information on matters impacting the role, mission, and long-term commitments of the Center. Policy implementation vehicles for technology transfer include the Center's Office of Research and Technology Applications (ORTA), the Navy/Industry Cooperative Research and Development (NICRAD) Program, and the Federal Laboratory Consortium for Technology Transfer. The Industry Independent Research and Development (IR&D) Program is also a contributor to technology transfer activities, since the transfer process can involve a two-way exchange between Government and non-government organizations. The IR&D Program serves to inform government technologists about industry-initiated research and development projects of interest and applicability to the Department of Defense; it also serves as a mechanism for government researchers to appraise the progress and relevance of industry-initiated effort. Technology transfer management functions include:

- (a) coordinating the program within the Center;
- (b) maintaining external liaison (with the Office of Chief of Naval Research, the Federal Laboratory Consortium for Technology Transfer, the Department of Commerce, other Federal agencies, state and local governments, universities, and private industry);
- (c) preparing Technology Application Assessments;
- (d) assisting potential user organizations in formulating their problems;
- (e) providing and disseminating information on federally owned or originated products, processes, and services having potential application to state and local governments and private industry; and
- (f) providing technical assistance in response to requests from state and local governments.

(2) Technical Effort

(a) Project Work. Directly attributable and quantifiable technology transfer work performed by Center technical departments is generally represented by those projects funded by other Government (non-DoD) sponsors and private parties (excluding that effort funded by DoD contractors). This type of effort has manpower and funding allocations that are directed towards a specific objective or requirement per sponsor request.

(b) Technological Disclosures. In its role as a major Government R&D center, NSWC also serves as a significant contributor to Federal technology transfer in a more generic nature via technological disclosures in the open literature such as patents, reports, journals, and participation in symposia. The benefits from this type of activity accrete as spin-offs from DoD mission-related projects that are supported by Federal R&D appropriations. Although it is less tangibly measurable than technology transfer contributions of direct project work involving end-products, the long-term benefits are more highly promising since they provide the innovative community with a broad spectrum of new stimuli to promote economic, technical, and quality-of-life growth in the private and public sectors.

(3) Navy-wide Services. The Center also manages, edits, and publishes the "Navy Technology Transfer Fact Sheet." This monthly publication highlights Navy-wide technology and developments that have the appropriate approval for public release and are of potential benefit to public and private organizations, individuals, and other Federal laboratories. The program is sponsored by the Office of Chief of Naval Research (Code 01223) to provide a highly visible source and focus for the dissemination of domestic technology transfer contributions from the Navy laboratory community.

c. Program Funding Source. A summary of FY85 funding support for management activities and project work performed by the Center technical departments is presented below:

	<u>FY85 (\$K)</u>
(1) Administrative Functions	
ORTA	20
Other Technology Transfer	25
Technical Publications Division	190
(2) Technical Projects	
Protection Systems Department	75
Weapons Systems Department	85
Strategic Systems Department	50
Research and Technology Department	683
Underwater Systems Department	<u>125</u>
Total	1253

d. The following technology transfer related policy directives are in effect at NSWC:

(1) NAVSWCINST 5700.2A of 6 Jan 1986; Subj: Office of Research and Technology Applications (ORTA). The purpose of this instruction is to establish the Center ORTA.

(2) NAVSWCINST 3900.3 of 13 October 1981; Subj: Industry Independent Research and Development (IR&D) Program.

(3) NAVSWCINST 3900.1A of 22 December 1981; Subj: Navy/Industry Cooperative Research and Development (NICRAD) Program. The purpose of this instruction is to establish procedures for processing NICRAD agreements in accordance with NAVMATINST 3900.14. The NICRAD Program is technically not an element of the Navy's Domestic Technology Transfer Program. Frequently, it involves the exchange of sensitive and classified information to authorized contractors. Nevertheless, transfer of technology is involved. Therefore, for administrative purposes this program is included as a functional element of the NSWC Technology Transfer Program.

e. The Center point-of-contact for ORTA, the IR&D Program, and the NICRAD program is Mr. Ramsey D. Johnson, Code D21, (301) 394-1505 or Autovon 290-1505.

## 2. ACCOMPLISHMENTS AND CURRENT EFFORTS SUMMARY

a. Narrative summaries of NSWC technology transfer related projects involving FY85 effort are presented in Appendix A.

b. The following report, which describes recent Center accomplishments and efforts, was published for public release:

NSWC MP 85-58, Naval Surface Weapons Center Technology Transfer Biennial Report (FY83/84).

c. For the FY85 period, three Technology Application Assessments were submitted to the Office of Chief of Naval Research as inputs for the Department of Commerce, National Technical Information Service. These items are presented in Appendix B and are listed below:

- (1) Software Reliability Analysis
- (2) Magnetic Detection
- (3) Real Time LAN Communications

## 3. INFORMATION DISSEMINATION AND WORKING RELATIONSHIPS

a. NSWC is a member of the Federal Laboratory Consortium for Technology Transfer and participates in meetings, symposia, and exhibits related to technology transfer activities involving the Navy, state and local governments, and private industry.

b. NSWC publishes and contributes to the "Navy Technology Transfer Fact Sheet." FY85 inputs to this document are listed below:

- (1) Self-Powered Vehicle Detector
- (2) Surface Roughness Technique for Wind Tunnel Modeling
- (3) Grounding System for Chassis Connectors

c. In October 1984 NSWC participated in the "Opportunities Through Technology Transfer" conference at the University of Pittsburgh's Bradford, Pennsylvania campus. This conference was supported by the NASA Industrial Applications Center to provide an advanced technology awareness and adaptation program structured to enhance the competitive posture of business and industries in the Bradford, Pennsylvania area.

d. NSWC entered into the following 17 NICRAD Program Policy Agreements in FY85:

<u>COMPANY</u>	<u>PROJECT TITLE</u>	<u>EFFECTIVE DATES</u>
(1) Optoelectronics, Inc.	Epitaxial Thin Film Infrared Detectors	11/84 to 10/87
(2) Aerojet Ordnance Company	Navy Warheads Requirements Study	12/84 to 11/87
(3) D.R. Kennedy & Associates, Inc.	Navy R&D Requirements Study	1/85 to 1/87
(4) Honeywell, Inc. -- Marine Systems Division	New Generation Mine Technology Study	1/85 to 12/87
(5) General Electric, Ordnance Systems Division	Technology Application to Naval Surface Warfare Requirements	11/84 to 10/87
(6) FMC Corporation, Northern Ordnance Division	Undersea Warfare -- Torpedo Warhead Concepts	1/85 to 12/87
(7) Raytheon Company, Missile Systems Division	Guided Projectile Technology Exchange	2/85 to 1/88
(8) General Electric Company, Military Electronic Systems Operations	Local Defense Requirements	3/85 to 2/88
(9) Damaskos, Inc.	IR Signal Reducing Coatings	6/85 to 5/88
(10) General Electric Company, Armament & Electrical Systems Dept.	Navy R&D Requirements Study	6/85 to 5/85
(11) Lockheed Electronics Co., Inc.	Shipboard Surface Warfare Command & Control System	4/85 to 3/88

(12) Vitro Corporation	Applications of Artificial Intelligence Techniques to the Surface Action Group (SAG) Mission	4/85 to 3/88
(13) E-Systems, Melpar Division	Proposed Electronic Warfare Architecture Utilizing Expert Systems Technology	4/85 to 3/88
(14) FMC Corporation, Northern Ordnance Division	Track Processing for Surface Naval Command & Control and Fire Control	7/85 to 6/88
(15) United Technologies Corp., Hamilton Standard Div.	Navv R&D Requirements Study	9/85 to 8/88
(16) Hazeltine Corporation	Naval Color Monitor Applications	6/85 to 5/88
(17) Brimrose Corporation	Manufacture of Digital Dosimeters	9/85 to 8/88

e. Inventions and patent disclosures by NSWC in FY85 with potential technology transfer applications totaled 22. These are listed in Appendix C. NSWC also contributed approximately 425 unrestricted information disclosures via various media such as symposia, workshops, journals and other publications.

f. In 1985 106 NSWC technical publications were entered into the National Technical Information Service (NTIS) data base.

g. In support of government and academic institutions, the NSWC ORTA responded to requests for technical information from the following organizations:

- (1) Bradford, Pennsylvania (technology transfer conference participation)
- (2) California State University (eddy current technology; fiber optics connector)
- (3) Colorado School of Mines (Surface Evaluation Facility)
- (4) Iowa State University/Ames Laboratory (magnetostrictive materials)
- (5) Battelle Pacific Northwest Laboratory (high temperature electronics systems)

h. The NSWC ORTA responded to technical information requests from individuals and private industry in the following technology areas:

- (1) Fiber optics cable connector

- (2) Magnetostrictive transducer
- (3) Metal matrix composite materials (improved battery grids)
- (4) Magnetic detection (Self-Powered Vehicle detector)
- (5) Biodegradability of explosive material
- (6) High temperature electronics components
- (7) Aerodynamics and electronics testing facilities

i. Numerous inquiries are made directly to Center staff members within the various technical departments. The resultant responses significantly contribute to the Center's technology transfer process, although they are not formalized within the ORTA function.

APPENDIX A

NARRATIVE SUMMARIES FOR NSWC FY85 TECHNOLOGY  
TRANSFER RELATED PROJECTS

1. MANUFACTURING TECHNOLOGY

a. The Navy Manufacturing Technology Program requires that technology transfer to the private sector and Government agencies be a major activity of each funded project. Accordingly, upon completion each project is required to have an end-of-project demonstration for potential users or vendors, and to issue a final report. In both instances, efforts are made to disseminate the information to the widest possible audience. However, some of the information is classified and some is unclassified but associated with critical, sensitive technologies. This information is not releasable for public information and such requests are individually assessed regarding the extent to which information may be disseminated. Within this constraint each project manager is encouraged to actively communicate with interested parties during the project to transfer the developing technology.

b. In addition to technical project work, NSWC also provides technical and administrative program support to the Office of Naval Acquisition Support and the Naval Sea Systems Command for manufacturing technology programs in cost benefit tracking, combat systems and robotics.

c. The following Manufacturing Technology programs are on-going at NSWC:

- (1) Graphite-aluminum tape and tooling
- (2) Advanced neutron radiography
- (3) Multicolor epitaxial thin-film infrared detectors
- (4) Reinforced lead acid battery grids
- (5) Passive 3-D vision for robotic applications
- (6) Metal Matrix Composites (MMC's)
  - (a) continuous MMC's
  - (b) discontinuous MMC's
  - (c) space structures applications
- (7) Carbon-carbon materials
- (8) Carbon fibers

(9) Mechanically alloyed aluminum

(10) Laser materials processing

## 2. SOLID ROCKET BOOSTER (SRB) HAZARD STUDY

NSWC has supported NASA, Marshall Space Flight Center, for several years during the development of the Command Destruct System (CDS). The current effort has been ongoing since FY83. The effort has investigated the interaction between the CDS Linear Shaped Charge during destruct action and the propellant grain for both the new carbon-carbon filament wound case and the presently-flying steel case. A progress report was transmitted to NASA during FY84. The experimental program had the following work elements: (1) Linear Shaped Charge Performance Tests, (2) Material Response Testing, including uniaxial high strain rate tests, (3) Structural response, evaluating the fragmentation effects of the filament wound case, and (4) Detonability/Shock Sensitivity Studies. This effort was completed in FY 85 and a draft final report submitted to NASA. Based on all of the field and laboratory testing which has been conducted, the conclusion is that the activation of the CDS will cause, at worst, a burning in the propellant. This burning will not transmit to detonation. The most likely occurrence is a mild pressure burst in which the region of damage adjacent to the LSC will burn rapidly.

## 3. NASA SPACE SHUTTLE FRAGMENT HAZARDS

a. The Galileo and Ulysses spacecraft, each with a Centaur rocket motor, are to be carried into earth-orbit by the space shuttle. The Galileo has two Radioisotope Thermoelectric Generator (RTG) units, and the Ulysses has one RTG unit. A radioactive spill could occur if an accident broke open an RTG unit. Certain in-flight accidents could cause a detonable mixture of the LOX and LH<sub>2</sub> fuels from the Centaur rocket motor. Such a detonation could accelerate objects and fragments to impact the RTG units at high velocities.

b. NSWC provided technical assistance to the Johnson Space Flight Center, NASA to define the blast loading and fragment hazard for the RTG units due to spillage and detonation of liquid propellant fuel from the Centaur rocket motor while within the space shuttle cargo bay. The TUULI computer code was used to determine the blast loading when the RTG is at some distance from the explosion source, and also for cases of complex geometry. The methodologies in the Naval Explosives Safety Improvement Program (NESIP) technology base were used to determine blast loading close to the source where mass effects are important. The blast loading and fragment hazard predictions were successfully completed and delivered to NASA.

## 4. HYDROBALLISTIC FACILITY

NSWC provides a hydrodynamic testing facility for use by Federal agencies and private industry. The parallelepiped test tank has inside dimensions of 100 feet in length, 35 feet in width, and 75 feet in height. Water depths up to 65 feet are possible while the normal depth is 60 feet. A major feature of the tank is the ability to create a vacuum above the water surface which provides the proper conditions for correct scaling of model tests. Photographs may be taken through the 152 viewing ports located on three sides, and top and bottom

of the tank or by existing underwater systems. During FY85, test services were supplied to NASA to support the Space Shuttle Program and to a number of contractors who tested several systems.

## 5. GPS GEODETIC RECEIVER SYSTEM

a. Using the signals from the Global Positioning System (NAVSTAR) Satellites, the GPS Geodetic Receiver System will provide remote real time point positioning approaching 1 meter accuracy in 4 to 6 hours versus 24 to 36 hours using the Navy Navigation Satellite System (TRANSIT). Relative positioning determination between 2 sites, 100 to 250 kilometers apart, will approach 2 centimeters in accuracy after approximately 4 hours on site, and 4 meter positioning accuracy will be typical when the Receiver System is used on a low dynamic survey vessel or aircraft. These are requirements that the sponsors, Department of Interior (U.S. Geological Survey); Department of Commerce (NOAA-National Geodetic Survey); and Defense Mapping Agency, have placed on the Receiver System. An attractive feature of the Receiver System is its software controllability, offering relatively easy adaptation for either special geodetic or nongeodetic applications.

b. NSWC was selected to direct the Receiver System development due to its previous geodetic work with TRANSIT and continuing work with GPS. In addition, NSWC has developed the first set of fixed position solution software and is integrating it in the hardware.

## 6. HIGH ALTITUDE PARACHUTE DEPLOYMENT

a. NSWC provided technical expertise and engineering design coordination to NASA, Goddard Space Flight Center, for a high altitude parachute deployment (90km region) and recovery program. NASA uses parachute systems to make various scientific measurements around the world (e.g., Alaska, Norway, Peru). The various systems are tailored to particular test requirements, including in-flight recovery via aircraft snatch of the descending parachute. Center participation included support in the following areas:

(1) modifications to parachute systems (redesign of panel attach points, installation of radial load lines, redesign of parachute riser to incorporate attach point for load lines, and design and installation of crown area load lines);

(2) systems drawings and packing procedures and techniques;

(3) flight test participation (with post-test analysis of unsuccessful recovery attempt, and recommended fixes); and

(4) parachute packing supervision. No failures have occurred since NSWC involvement began.

b. During FY85, NSWC also contributed consulting services and in some cases technical assistance to the following industrial firms in the areas of aerodynamics, structures, packing, and deployment:

- (1) Hycor Corporation
- (2) Hi-Shear Corporation
- (3) SCI Corporation
- (4) Honeywell Corporation
- (5) Johns Hopkins Applied Physics Laboratory

c. NSWC published the following report related to parachute technology:

(1) Alternate Altitude Testing of Solid Cloth Parachute Systems, NSWC TR 85-24

#### 7. DEPARTMENT OF TRANSPORTATION (COAST GUARD) SUPPORT

a. In response to a request for technical assistance, NSWC provided a representative to investigate the condition of a 3"/50 gun barrel aboard the USCGC DURABLE. Inspection revealed no damage in the gun barrel, chamber or bore other than normal conditions expected given the number of rounds fired with the weapon. Continued firings with the barrel can be safely conducted.

b. NSWC conducted structural test firings (STF) on board the United States Coast Guard (USCG) cutters BEAR (WMEC 901) and USCG TAMPA (WMEC 902) during FY 84 and FY85. This program ensures that the ships meet safety and structural requirements in the 75mm gun blast areas. Additional 76mm gun firings were conducted to gather engineering data on ship structure and Carbon Monoxide entry into ship compartments.

#### 8. TOURMALINE GAGES

a. The original tourmaline gage was designed and developed under Navy contract at Woods Hole Oceanographic Institute during World War II. These gages are used in the measurement of shock wave phenomena from underwater explosions. After the war, scientists formed Crystal Research Company to market the gage; the company closed in 1972. NSWC purchased the company assets and began producing gages to fill the void left by the defunct company. Improvements have been made to the gages in relation to evolving technology.

b. NSWC constructs and calibrates the gages which are sold at fixed price to various Government and industry research activities. Gages and related information are exchanged with foreign governments with whom the U.S. has information exchange agreements. Gage purchasers have included the Department of Interior (Bureau of Mines); Elda Trading Corp.; Battelle; IRECO Chemicals; Gulf Oil Chemicals; Nitrochem Energy Corp.; and Safety Consulting Engineers.

#### 9. COMPUTER SCIENCE RESEARCH CONSORTIUM

a. The Computer Science Department at the Virginia Polytechnical Institute and State University (VPI/SU) has formed a Computer Science Research Consortium (CSRC) program to strengthen existing professional relationships and create new ones between VPI/SU professors and the Government and industry technical user community. NSWC is a member of this consortium and provides a representative for the CSRC's steering committee. Mutual benefits of the program include:

- (1) providing a resource of quality graduates to academia, industry, and Government;
- (2) promoting Government/academia personnel exchanges;
- (3) providing feedback for orienting teaching requirements toward real-life applications;
- (4) providing an increased awareness of outside requirements to help focus academic research efforts.

b. During 1985 the Consortium has sponsored the following events that promote technology transfers:

- (1) A semiannual newsletter containing articles on current research activities;
- (2) A computer science open house in September with a technical exposition of research activities; and
- (3) A catalog of technical reports from the Virginia Tech's Computer Science Department.

#### 10. SYSTEMS RESEARCH CENTER AT VPI/SU

a. In 1983 NSWC, the Naval Sea Systems Command (NAVSEA) and VPI/SU established a Systems Research Center at the University under NAVSEA sponsorship. The Systems Research Center conducts research jointly with and in support of the scientific staff at NSWC. During the first year of operation, a computing facility with classified operating mode has been set up, and eleven projects have been established with a total funding of about \$1.5 million. Eight of these projects involve NSWC.

b. The research activities add to the scope and breadth of the university's research program and produce additional equipment and educational opportunities for both faculty and students. The government is benefiting from this Center by strengthening and expanding the association of the Navy and VPI/SU. This joint effort supports computer science and computing technology, which are becoming increasingly important in modern naval applications.

#### 11. IMPACT SENSITIVITY TESTS

a. NSWC provides explosive facilities testing support to other Government agencies and industry. In FY85, the Department of Energy funded NSWC to conduct SUSAN impact tests to determine the sensitivity of various explosives. The SUSAN test technique is a method of assessing the sensitivity of explosives to shock and crushing impact. This method utilizes larger quantities of a test explosive than most other methods of sensitivity assessment, and is considered to duplicate more exactly the reactions of larger masses of explosives to shock and crushing impacts.

b. The SUSAN test involves gun-firing explosively loaded projectiles at various velocities against a steel target, and assessing the reaction of the

explosive. Using high-speed photography and overpressure measurements, the SUSAN test allows of the following two specific properties of an explosive which are the basis for the ranking of explosives according to impact sensitivity:

(1) Ignition properties -- how easily is an explosive ignited by mechanical work.

(2) Propagation properties -- after the explosive has been ignited, what tendency does an ignition have to grow to larger reactions.

## 12. EXPLOSIVE TRANSFER LINE EVALUATION

a. NSWC has participated in a service life extension program conducted on rigid explosive transfer lines. Rigid explosive transfer lines, commonly called shielded mild detonating cord (SMDC) are the most extensively applied components in aircraft crew escape systems. These lines are normally used to interconnect the components of emergency escape functions. More than one million cords have been manufactured for various aircraft, spacecraft, and missiles, which include the Army AH-1, the NASA/Army Rotor Systems Research Aircraft (RSRA), the NASA Space Shuttle, the Air Force F-111, F-15, F-16, and B-1 and the Navy TA-7, S-3A, F-14, and F-18. The purpose of this ongoing-joint Army, Air Force, NASA program is to quantitatively determine the effects of service, age, and degradation on SMDC lines to allow responsible and conservative service life determinations. Significant savings in the cost of (1) HNS and DIPAM rigid explosive transfer lines, (2) manhours needed for pyro change-out time, and (3) aircraft down time can be realized for military and NASA aircraft by extending the service life of these lines.

b. NSWC has developed techniques for the chemical and photographic characterization of HNS and DIPAM explosives contained in shielded mild detonating cords, flexible linear shaped charges, and one-way transfer units using high performance liquid chromatography, scanning electron microscopy, and macrophotography. A method to determine both total and surface moisture using nuclear magnetic resonance spectroscopy has also been developed. Samples have been evaluated for the Air Force, NASA, and the Navy.

## 13. POSITRON LIFETIME STUDY

This research study, funded by NASA (Langley Research Center), was directed toward nondestructive evaluation of composite materials; it involves the extension of the technique from the study of fatigue in metals to the study of moisture in polymer resins. Positrons emitted from a suitable radioactive source enter a specimen of resin matrix composite or other polymeric material, and interact with negative electrons in the host material to produce annihilation gamma rays. The time between positron injection and emission of gamma rays (on the order of a few nanoseconds) has been shown to be dependent on the amount of absorbed moisture in the specimen. This technique is being studied for potential use in monitoring environmentally absorbed moisture (in resin-matrix composites) that can affect mechanical properties. The effects of chemical additives (such as metal ion complexes) on the water absorption processes in polymers is also being studied using the positron lifetime technique. NSWC provided data acquisition and data analysis support from FY81 to FY85. Results of recent work are published in Nuclear Instruments and Methods, Vol. 221, No. 2, 1 April 1984, and in NASA Technical Memorandum 86431, May, 1985.

## 14. U.S. COAST GUARD DIVING EQUIPMENT PROGRAM

The Coast Guard Diving Program was initiated in 1977 for the purpose of bringing Coast Guard diving equipment and procedures into conformance with Navy standards. This was accomplished by 1980. The primary effort since that time has been to provide technical support in the areas of design, development, selection, and installation of diving equipment. In FY85 support was provided in the design and installation of two shipboard diver's air systems, the safety survey of diving units, and the purchase of a variety of diving equipment.

## 15. UNDERSEA WEAPONS TANK

NSWC provides an underwater testing facility for the use of Federal agencies and industry. The Undersea Weapons Tank is 50 feet in diameter and 100 feet deep. A major feature is the retrieving platform or false bottom, operating to the 100 foot depth and providing quick recovery of the test units. There are six viewing platforms around the outside of the tank. During FY85 test services were supplied to NOAA to support polluted water diving tests, and to a number of contractors who used the facility to test various systems.

## 16. HYDROGEN GAS GENERATOR

Based on previous NSWC experience in the development of hydrogen gas generators as power supplies for actuators and fluidic sequencers, the Department of Interior, Geological Survey funded NSWC to develop such a power supply for an underwater cavitation erosion gun which could be used for cleaning off-shore structures used for oil exploration. A prototype generator was developed in FY82. FY83 effort was limited to test preparations and material procurement due to funding limitations. Feasibility testing was initiated in FY84 and continued into early FY85. Although funding limitations curtailed testing in FY85, it is anticipated that funds will be available to complete the testing in FY86.

## 17. NITINOL RESEARCH ASSIST

a. NITINOL, invented at the Naval Ordnance Laboratory (now NSWC), is an alloy of nickel and titanium that can recover a prior shape. This characteristic can be illustrated by bending a sample of the material into a new configuration when it is at ambient temperature; it can then be returned to its original shape by slightly heating it. This is known as the "shape memory effect." When NITINOL undergoes shape recovery it exerts considerable force; it has generated stresses greater than 80,000 pounds per square inch when heated.

b. Changing its alloy composition during manufacture changes the temperature band at which the transformation occurs. The material is also corrosion resistant and non-magnetic. In FY85 NSWC produced and tested a small quantity of high transition temperature NITINOL in support of a non-government funded research effort.

## 18. RADIOGRAPHIC INSPECTION OF FUEL CELL INSULATORS

From FY81 to FY85 the Brunswick Corporation funded NSWC to perform radiographic inspection in the nozzle/fuel cell bonding area of the space shuttle propulsion system. Specifically, this involves the rubber liners for the

NSWC MP 85-458

shuttle oxidizer tanks. A double-film, two-level exposure technique is used to assess the bond at specific intervals around the periphery of the assemblies.

APPENDIX B

NSWC FY85 TECHNOLOGY APPLICATION ASSESSMENTS

<u>Title</u>	<u>Lab No.</u>
1. Software Reliability Analysis	NSWC-TAA-85-001
2. Magnetic Detection	NSWC-TAA-85-002
3. Real Time LAN Communications	NSWC-TAA-85-003



## TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory Naval Surface Weapons Center
2. Contact (ORTA) Ramsey D. Johnson  
Phone (301) 394-1505 Autovon 290-1505
3. Address Silver Spring, MD 20903-5000 (Code D21)
4. Technology Name Software Reliability Analysis
5. Technology Type: ☒ (a) Process ☐ (b) Apparatus ☐ (c) Material  
☐ (d) Service ☐ (e) Study ☒ (f) Other: Tool
6. Users: ☒ (a) Federal Government ☒ (b) State Government  
☒ (c) Local Government ☒ (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry ☒ (g) Consultant ☐ (h) Other: \_\_\_\_\_

A. Date: 9/30/85

B. CUFT #: \_\_\_\_\_

C. LAB #: NSWC-TAA-85-001

D. Descriptors:  
Software reliability modeling  
Interactive computer program  
Tool for software reliability analysis  
Software error  
Mean time between software errors  
Software reliability

E. Applications:  
Quality assurance of software  
Software testing  
Producing reliable software

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study, training adaptive eng., other: \_\_\_\_\_

8. What Problem Does It Solve and How? It helps to estimate the number of software errors still present in a piece of software based upon the number of errors that have been detected previously. It is a tool that can be used to determine when a piece of software can be released for operational use. It can also aid in determining the current reliability of the software.

9. Other Uses: It can be a useful tool in determining resource allocation of limited testing resources in doing verification and validation on a piece of software.

10. Main Advantages: Currently there is no tool available that allows the software analyst to enter software error data, model it using any of eight models appearing in the literature, and then determine the adequacy of the model fit.

11. Production Information: The only requirement for this interactive computer program for software reliability analysis is a computer with a Fortran IV or V compiler.

12. Descriptive Literature: "Statistical Modeling and Estimation of Reliability Functions for Software (SMERF's) User's Guide" NSWC TR 84-373. "A Survey of Software Reliability Modeling and Estimation" NSWC TR 82-171. "Statistical Modeling and Estimation of Reliability Functions for Software (SMERF's) Library Access Guide" NSWC TR 84-371

13a. Literature Available From: Dr. William H. Farr  
K52  
NSWC, Dahlgren, VA 22448  
(703) 663-8674

## 13b. Description:

## SOFTWARE RELIABILITY ANALYSIS

9/30/85

NSWC-TAA-85-001

An interactive computer program for software reliability analysis has been developed. The program is called SMERFS, which stands for Statistical Modeling and Estimation of Reliability Functions for Software. The computer program will run on any computer system (with some minor modifications) that has a Fortran IV or V compiler. Two versions of the program are available for a VAX or Cyber computer system with no modifications. The computer program allows the user to perform a complete software reliability analysis using any of eight well-known models appearing in the literature. Four of the models use as input data the time between software error occurrences, while the other four use the number of errors detected per testing period. The models that are currently incorporated into the program include: Littlewood and Verrall's, Moranda's Geometric, Musa's Execution Time Model, Goel's Non-homogeneous Poisson Process Model for time between error occurrence, Goel's Poisson Model for number of errors detected per testing period, a Generalized Poisson Model, Brook's and Motley's Model, and Schneidewind's Model.

The computer program is interactive in nature and allows the user to enter a set of data, modify it if necessary, fit an appropriate model, and determine the adequacy of the fitted model. The chosen model can then be used to estimate such parameters as: number of remaining software errors in the code, expected number of errors in the next testing period, length of time to remove the remaining number of errors, estimated reliability of the software, etc.

The program is described in the article "An Interactive Program for Software Reliability Modeling" appearing in the Proceedings of the Ninth Annual Software Engineering Workshop, November 1984, Software Engineering Laboratory SEL-84-004, NASA Goddard Space Flight Center. The computer program can be used in the testing and/or operational life cycle phase of a program's life cycle development.

Documentation including a user's guide is available upon request. Contact Dr. William H. Farr, K52, NSWC, Dahlgren, VA 22448, (703) 663-8674.



NSWC MP 85-458

## TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory Naval Surface Weapons Center
2. Contact (ORTA) Ramsey D. Johnson  
Phone (301) 394-1505 Autovon 290-1505
3. Address Silver Spring, MD 20903-5000 Code D21
4. Technology Name Magnetic Detection
5. Technology Type: (a) Process ☒ (b) Apparatus (c) Material  
☒ (d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government ☒ (b) State Government  
☒ (c) Local Government ☒ (d) Small Industry (e) Medium Industry  
☒ (f) Large Industry ☒ (g) Consultant (h) Other: \_\_\_\_\_

A. Date: <u>9/30/85</u>
B. CUFT #: _____
C. LAB #: <u>NSWC-TAA-85-002</u>
D. Descriptors: <u>Magnetic detection</u> <u>Vehicle detection</u> <u>Remote sensing</u>
E. Applications: <u>Detection of ferromagnetic</u> <u>materials (e.g., automobiles,</u> <u>trucks, railroad cars)</u>

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study,  
training, adaptive eng., other: \_\_\_\_\_
8. What Problem Does It Solve and How? Detection of ferromagnetic motor vehicles (cars and  
trucks) and railroad cars; can be used for remote monitoring and counting;  
vehicular traffic control
9. Other Uses: Mines (land and sea); ordnance locators and proximity sensors
10. Main Advantages: low power miniature Brown-type ring-core magnetometer
11. Production Information: SPVD (Self-Powered Vehicle Detector) - Request for proposal in  
1985 by Dept. of Transportation (FHWA) for prototype production
12. Descriptive Literature: NSWC TR 78-177 (Oct 1978); Title: Development of a Self-Powered  
Vehicle Detector; or, Dept. of Transportation Federal Highway Administration  
Report FHWA-RD-79-89 (same title)
- 13a. Literature Available From: DTIC #A0A068895  
NSWC  
Dept. of Transportation (FHWA) Mr. Charles Stockfish (202) 285-2368

## MAGNETIC DETECTION

9/30/85

NSWC-TAA-85-002

The Naval Surface Weapons Center, under the sponsorship of the Federal Highway Administration, has developed a battery-operated motor vehicle detection system. This Self-Powered Vehicle Detector (SPVD) may be buried in any type of road surface and uses a transmitter rather than hardwiring with its control unit. The detector reads a vehicle's magnetic signature, processes it, and transmits the vehicle's presence to the control unit. This control unit is located normally within the traffic signal cabinet, up to 1000 feet (the maximum range of the sensor's transmitter) from the sensor.

The sensor is designed to measure vehicle speed and vehicle count and relay this data by a radio frequency transmission to a remotely located control unit. The magnetic sensor is capable of determining vehicle speed from 0 to 80 miles per hour and counting up to 20,000 vehicles per day. It is designed to detect trucks, buses, automobiles, and motorcycles and to relay vehicle count and speed data to the associated control unit.

The Federal Communications Commission has allocated and assigned radio frequency channels for use with this traffic control system. The assigned radio frequency channels are in the 47 MHz band and there is no requirement for licensing, frequency coordination or user record keeping by users of the SPVD.

The 5x6x9 inch control unit requires a 115 volt 60Hz power source for operation. A quarter wave length whip antenna mounted external to the instrument cabinet and connected to the control unit receiver by a coaxial cable is also necessary. The control unit decodes data transmitted to it by the vehicle detector and uses this information for traffic signal control.

The SPVD is installed easily by using a standard core sample drill. It is placed below the surface in the center of the traffic lane to be monitored. Since the detector requires no wiring to the control unit, installation costs are very low. The battery has a nominal 2-year life expectancy.

The SPVD has an economic advantage over conventional systems because of its simplicity of installation and low operation and maintenance cost. The ease of installation of the sensor and its associated low installation cost make the system ideal for temporary or remote area use where the cost of conventional system installation and operation would be prohibitive.



NSWC MP 85-458

## TECHNOLOGY APPLICATION ASSESSMENT

1. Laboratory Naval Surface Weapons Center
2. Contact (ORTA) Ramsey D. Johnson  
Phone (301) 394-1505 Autovon 290-1505
3. Address Silver Spring, MD 20903-5000 (Code D21)
4. Technology Name Real Time LAN Communications
5. Technology Type: ☒ (a) Process ☒ (b) Apparatus (c) Material  
(d) Service (e) Study (f) Other: \_\_\_\_\_
6. Users: ☒ (a) Federal Government (b) State Government  
(c) Local Government (d) Small Industry ☒ (e) Medium Industry  
☒ (f) Large Industry (g) Consultant (h) Other: \_\_\_\_\_

A. Date: 9/30/85  
B. CUFT #: \_\_\_\_\_  
C. LAB #: NSWC-TAA-85-003  
D. Descriptors:  
Local Area Network Applications  
Real Time Communications  
Open Systems Interconnection  
\_\_\_\_\_  
\_\_\_\_\_  
E. Applications:  
Real Time Control  
Manufacturing Process Control  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

7. Potential Support: exclusive license, consulting, joint venture, drawings, tooling, computer prog., economic study, training, adaptive eng., other: \_\_\_\_\_
8. What Problem Does It Solve and How? The techniques being developed by NSWC allow for communications of a medium to a large number of "Smart" devices to communicate among themselves over a Local Area Network (LAN) in real time. The techniques work via a set of system-wide conventions that do not depend on the function of any one interconnected device.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
9. Other Uses: Process architecture: automated manufacturing processes requiring integration of multiple, remote computer-operated stations (e.g., robotics applications)  
\_\_\_\_\_  
\_\_\_\_\_
10. Main Advantages: Techniques are totally non-proprietary and the means for updating to improved LAN components has been developed.  
\_\_\_\_\_  
\_\_\_\_\_
11. Production Information: High-tech. Utilize LAN chip sets in use and in development by integrated circuit manufacturers now.  
\_\_\_\_\_  
\_\_\_\_\_
12. Descriptive Literature: Information will be available in FY86.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 13a. Literature Available From: Present point of contact - Dave Marlow; NSWC, Code N33 Dahlgren, VA phone (703) 663-4674  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## 13b. Description:

## REAL TIME LAN COMMUNICATIONS

9/30/85

NSWC-TAA-85-003

NSWC is investigating the implications of interconnecting computers used in tactical systems via a Local Area Network (LAN). Such computers perform control, decision and data processing functions in real-time shipboard combat systems. The ISO Open System Interconnection Model is being used as an overall model of communication among programs residing in different computers. At the lower two levels of this model, the LAN technology being emphasized is the broadcast data bus (e.g., IEEE 802.3 and 802.5) since this technology offers the potential for maximum flexibility in connection. At these two layers, LAN standards are being commercially developed (e.g., IEEE 802.3 and the ANSI X3T9 FDDI Token Ring) which provide for communication in the range of 10-100 Mbits/second; however, computers must be able to efficiently support all the actions required to transfer data among user processes to make such LAN's useful.

The focus of the NSWC work is to understand what is involved in computer communications at the middle and upper levels of the OSI model and with this knowledge develop techniques which will permit LAN connection for Navy tactical computers that meet the requirements of the real-time environment. Similar problems exist for any real time computer interconnection.

The issues discussed herein are crucial to achieving embedment of standards such as IEEE 802.3 into real time computers, interoperability of devices built by different manufacturers, as well as integrating elements (hardware and software) developed by different organizations into a working system. A primary goal is to understand and specify the range of functions needed to achieve such interoperability.

Another primary focus is to consider how LAN components (both hardware and software) will impact the design for interconnecting computers to form a real time system. Attention is being paid to the full top down system engineering implications since this should drive the component development.

Technical information on this development is available from Mr. David T. Marlow; Naval Surface Weapons Center (Code N33), Dahlgren, VA phone (703) 663-4675.

NSWC MP 85-458

APPENDIX C

NSWC INVENTIONS AND PATENTS IN FY85

TECHNOLOGICAL AREA	NAVY CASE OR PATENT NO.	TITLE AND PURPOSE	POTENTIAL COMMERCIAL APPLICATIONS
Oceanography and Biology	N.C. 67929	Expendable Bathythermograph for Measuring Light Attenua- tion Temperature Below the Ocean Surface	Oceanographic investigations
Explosives	N.C. 68847	Disintegrating Tamper Mass	Terrorist control: confined explosive for barrier penetration allowing quick entry into, or exit from, a reinforced wall chamber
Mining and Oil Exploration	N.C. 68321	Optical Fiber Magnetometer	Mineral and oil deposit location
Determination of Purity of Liquids	4,516,077	Apparatus for, and Method of, Measuring the Intrinsic Time Constant of Liquids	Maintaining purity of manufactured liquids during production
Gyroscopes	4,522,355	Apparatus for Scanning a Rotating Gyroscope	Navigation of ships and planes
Computer Simulation	4,484,266	Externally Specified Index Peripheral Simulation System	For training - connection of a simulation computer to a tactical computer
Shaped Charges	4,493,260	Annular Shaped Charge and Method of Breaching Masonry Walls	Reconstruction and rehabilitation of existing structures
Radiation Shielding	4,524,279	Radiation Source Shield and Calibrator	Power plants; nuclear processing
Electrical	4,488,139	Electrical Connector (to fabricate improved con- nector)	Electrical Connector

TECHNOLOGICAL AREA	NAVY CASE OR PATENT NO.	TITLE AND PURPOSE	POTENTIAL 'COMMERCIAL APPLICATIONS
Cloud cluttered background detection	67,718	Analog Spatial Filter for Detection of Unresolved Targets against a Cloud- Cluttered Background	Airplane collision avoidance
Robotics	66,279	Torque Gauge for Applica- tions including Robotics	Sensor for robotic arms
Electronic Card Assembly	68,055	Latch for Detachably Secur- ing Electronic Cards Along Orthogonal Loading Axes	For detachably securing electronic cards
Area Security	68,201	Quasi-Ultrasonic Intrusion Detector Method	Home and area security
Navigation	67,942	An Apparatus for, and a Method of, Determining Compass Headings	Navigation of transports such as ships or planes
Oceanography	68,782	High Output Programmable Signal Current Source for Low Output Impedance Ap- plications	Powering of oceanographic equipment
Microwave Transmission	68,866	Millimeter Wavelength Dielectric Waveguide Having Increased Power Output and a Method of Making Same	Microwave Communications
Laser Modulation	67,420	Analog Frequency Modulated Laser Using Magnetostriction	Laser Communications Systems
Batteries	N.C. 68470	Polyethylene Iminemetal Salt Solid Electrolyte	Batteries

TECHNOLOGICAL AREA	NAVY CASE OR PATENT NO.	TITLE AND PURPOSE	POTENTIAL COMMERCIAL APPLICATIONS
Lasers	4,506,368	Dye Lasers Using 2-(4-Pyridyl)-5-Aryloxazoles and Quaternary Salts of the Compounds (Blue-Green Wave-lengths)	Tuneable liquid dye lasers for underwater communication, surveillance, etc.
Organic Solvents	N.C. 68245	Method of Preparing Tetrahydrofuran	Commercial organic solvent
Batteries	N.C. 67,675	Suspension Method of Impregnating Active Material into Composite Nickel Plaque	Lightweight nickel and cadmium electrodes
Batteries	N.C. 68240	Cobalt Treatment of Nickel Composite Electrode Surfaces	Lightweight nickel and cadmium electrodes

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